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Soil Temperatures and Suckering in Burned and Unburned Aspen Stands in Idaho

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ABSTRACT

Monthly average soil temperatures in a burned aspen stand ranged from 0 to 8 °F higher than in the unburned stand at depths to 12 inches for a site in southeastern Idaho. From June through August the first year after burning, soil temperatures were significantly different at all depths in burned and unburned stands. By the second and third years after burning, temperatures were not significantly different for most months. Temperatures were favorable for sucker initiation on burned plots. A hypothesis for a temperature threshold of 60 °F for sucker initiation is discussed.

KEYWORDS: *Populus tremuloides*, quaking aspen, root suckers, temperature, fire

SOIL TEMPERATURE AND SUCKERING

Many quaking aspen (*Populus tremuloides* Michx.) stands in the West are overmature and decadent, with conifer, shrub, and grass successional stages replacing aspen (Mueggler 1985). Historically, most even-aged aspen stands appear to be the result of fire (Jones and DeByle 1985) and thus seem to require a disturbance such as fire or cutting for rejuvenation. Aspen trees are extremely sensitive to fire because of their thin bark. Most stems are killed by fire (Jones and DeByle 1985), which in turn stimulates suckering from the roots. Death of the stems alters hormonal balance in the trees, and the light and temperature regimes at the soil surface. Aspen stands provide valuable wildlife habitat, livestock forage, watershed protection, and esthetic and recreational opportunities; thus managers want to maintain aspen as a dominant seral forest type.

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Clearcutting, burning, and scarification of aspen sites in Canada caused significant increases in soil temperature at the 0- to 1-inch depth (Maini and Horton 1966a; Steneker 1974). Canopy removal by burning and harvesting treatments in other community types also resulted in significant increases in soil temperature (Ahlgren 1981; Cochran 1975; Hungerford and Babbitt 1987; Shearer 1967). Some mitigation of temperature extremes can be provided by surface slash (Edgren and Stein 1974; Hallin 1968; Shearer 1967), which shades the surface. Regrowth of vegetation also mitigates temperature increases, but the timing varies between ecosystems (Ahlgren 1981; Hungerford and Babbitt 1987). These results suggest that burning would increase soil temperature in the northern and central Rocky Mountain aspen stands, but no published results are available to indicate the magnitude of temperature increases.

The mountainous and high-elevation character of the aspen sites in the northern and central Rockies contributes to much more variability in environmental conditions than is observed in Canada or the Lake States. On some sites (for example, steep north aspects at high elevations) soil temperature may be low enough to limit suckering regardless of treatment. Zasada and Schier (1973) suggested that aspen stands in Alaska are chiefly located on southern exposures because soil temperatures are suitable for suckering. In Wyoming, daily average temperatures in July (at a soil depth of 2 inches) were seldom above 60 °F on a high-elevation lodgepole site on a broadcast-burned clearcut (Hungerford and Babbitt 1987). Because the topography and climate of this lodgepole pine (*Pinus contorta* Dougl.) site is similar to many aspen sites, the results suggest that soil temperatures may be marginal for suckering in some northern and central Rocky Mountain aspen stands.

Soil temperatures affect the formation and development of suckers (Maini and Horton 1966a, 1966b; Steneker 1974; Williams 1972; Zasada and Schier 1973). Warmer temperatures stimulate cytokinin production by the roots (Williams 1972) and may cause degradation of auxin

(Schier and others 1985). Temperature influences suckering by altering the cytokinin-to-auxin ratio (Peterson 1975; Winton 1968; Wolter 1968). Once apical dominance is broken, increased soil temperatures stimulate suckering (Steneker 1974). Temperature also affects the number of suckers per root segment (Maini and Horton 1966a; Zasada and Schier 1973). Most field studies utilized maximum temperature measurements (Maini and Horton 1966a; Steneker 1974). Zasada and Schier (1973) found that low soil temperatures inhibit sucker development, which may explain the absence of aspen on cooler sites in Alaska. Maini and Horton (1966b) concluded that temperatures less than 60 °F or greater than 95 °F inhibit suckering. Zasada and Schier (1973) indicated that the diurnal change, rather than maximum, may influence suckering and low minimums may suppress suckering regardless of maximums. Published results do not make it clear how temperature influences suckering under field conditions. The relationship of temperature with hormonal balance as it interacts with clonal variability, root depth, etc., is unclear. The temperature threshold also may vary by clone (Maini 1968; Zasada and Schier 1973).

This case study reports soil temperatures in burned and unburned aspen stands at the surface to 12 inches in depth. Differences between the burned and control treatments are presented. Observed temperatures and sucker response (Brown and DeByle 1987) are discussed relative to the published suckering temperature threshold.

TEST SITE AND TREATMENT

The Manning Basin site is located in southeastern Idaho, 10 miles southwest of Afton, WY, on the Caribou National Forest. Aspect is southeast on a 40 percent slope at 7,350 feet. Before treatment the stand consisted of nearly pure aspen, with 250 stems per acre larger than 2 inches in diameter. Saskatoon serviceberry (*Amelanchier alnifolia*), evergreen ceanothus (*Ceanothus velutinus*), pachistima (*Pachistima myrsinites*), sticky geranium (*Geranium viscosissimum*), and butterweed groundsel (*Senecio serra*) are the dominant understory species. The community type (Youngblood and Mueggler 1981) is *Populus tremuloides/Prunus virginiana* (POTR/PRVI).

Climate is continental, with cold winters and warm summers. Average annual precipitation is 25 inches, and the July average temperature is 58 °F.

The Manning Basin site was treated with prescribed fire; an adjoining unburned stand was the control. Burning occurred on September 21, 1981, and covered 300 acres (Brown and DeByle 1987). Tree boles were charred extensively and all trees were killed. This degree of char and mortality indicates a severe burn according to the Ryan and Noste index (Ryan and Noste 1985).

TEMPERATURE MEASUREMENT

Temperatures at the surface of the soil and to depths of 12 inches were measured from 1 month after burning through part of the third year following burning. Temperature sensors were installed in burned and unburned treatments having comparable exposures at the following depths:

- surface: two sensors on litter or ash
- 1-inch: one sensor in soil
- 2-inch: one sensor in soil
- 4-inch: one sensor in soil; one in aspen root
- 8-inch: one sensor in soil
- 12-inch: one sensor in soil

First a hole with one smooth vertical face was dug. Sensors were pushed horizontally into the undisturbed soil on the vertical face at the proper depths. A hole the same diameter as the sensor was drilled in an aspen root, then the sensor was inserted. When the six soil sensors were in place, the hole was filled and tamped. Material that came from the surface—ash, duff, twigs, leaves, etc.—was restored to its original position. Surface sensors were placed on undisturbed litter or ash. The sensors were covered with ash or litter—just enough that the metal sensor tip was not exposed.

Thermistor beads (0.064-inch diameter) encased in 0.5- by 0.094-inch diameter stainless steel tubing were used as sensors. Six-foot lengths of shielded wire connected the temperature sensors to a junction box in each treatment. Each junction box was connected to a multichannel data acquisition system with a multiconductor cable. The data acquisition system controlled the sampling interval and recorded the temperatures on a cassette tape.

The data aquisition system recorded temperatures every 2 hours from October 1981 through July 1984. Technicians checked the installation and operation of the system several times during each of the two operating seasons and removed data tapes in the fall and spring. New sensors were installed as necessary at the surface. Nonfunctional sensors in the soil were not replaced, to avoid disturbing the soil.

ANALYSIS

Temperatures were compared between the burned and unburned treatments using pairwise *t*-test comparisons at the 0.05 significance level for each depth. Maximum and average temperatures at the surface and average temperatures for all depths beneath the surface were used for the tests. Suckering response for the two treatments reported by Brown and DeByle (1987) is compared to the observed maximum, average, and range of temperature. These temperature regimes and the sucker response in the burned treatment are compared to the hypothesized 60 °F temperature threshold.

SOIL TEMPERATURES AFTER BURNING

Average temperatures on the burned treatment were significantly higher than on the control at the surface and at depths from 1 to 12 inches during the summer (June through August) of year 1 (table 1). By September the differences were not significant. Temperature differences were small in the summers of year 2 and 3 and although statistically significant in some cases, the differences likely were not great enough to be biologically significant.

Table 1—Monthly average temperatures (°F) at different depths for burned (B) and unburned (UB) treatments at Manning Basin in 1982 and 1983. Values having different letters are significantly different at $p = 0.05$

Depth	June		July		August		September	
	B	UB	B	UB	B	UB	B	UB
1982								
Surface	62a	54b	63a	59b	65a	60b	49a	50a
1 inch	54a	50b	60a	55b	57a	57a	48a	48a
2 inches	54a	50b	—	54	—	56	—	48
4 inches	52a	48b	58a	54b	57a	56b	49a	48a
8 inches	49a	46b	55a	51b	55a	53b	49a	48a
12 inches	48a	45b	55a	50b	55a	53b	50a	48b
1983								
Surface	55a	52b	[1]57a	[1]56a	59a	60a	50a	51a
1 inch	50a	50a	—	[1]54	58	—	49	—
2 inches	—	48	[2]55a	[2]53a	58a	57b	50a	50a
4 inches	—	—	[2]54a	[2]52a	59a	56b	50a	50a
8 inches	48a	45b	[1]51a	[1]48b	56a	53b	50a	49a
12 inches	—	45	—	[1]48	56a	53b	51a	49b

[1]18 days.
[2]7 days.

Daily average temperatures on the burned treatment exceeded 60 °F from 0 to 17 days per month in June through August of year 1 at the 1- to 4-inch depth (table 2). On the control, daily average temperatures exceeded 60 °F for only 4 days at the 1-inch depth. Differences between treatments were greatest in July (fig. 1), when more days above 60 °F were measured than for other months (table 2).

Surface temperatures reached as high as 153 °F and exceeded 122 °F on the burned treatment for 41 days from May through August of year 1. Surface temperatures on the control reached 140 °F in May, but once the aspen leafed out maximums declined to less than 110 °F. Daily maximum temperature differences of as much as 37 °F were observed between treatments (fig. 2) for July of year 1. By year 3, dense understory vegetation and 4,500 to 15,000 suckers per acre shaded the surface. This shade reduced maximum surface temperatures on the burned treatment so they were significantly less (or not significantly different) than on the control.

Daily maximum temperatures on the burned treatment and control exceeded 60 °F on most days (June through August) at the 1- and 2-inch depths in year 1 (table 2) and frequently in years two and three. At the 4-inch depth, maximum temperatures on the burned treatment exceeded 60 °F on most days (June through August) and from 4 to 26 days (June through August) on the control. Daily maximum temperatures varied considerably by depth (fig. 3).

Minimum temperatures on the burned and control, at depths from 1 to 12 inches, ranged from 34 to 57 °F during June through August of year 1. Monthly average minimums ranged from 41 to 55 °F for the same period. In July, average monthly minimums at depths from 1 to 12 inches ranged from 52 to 54 °F in the burned treatment and 49 to 50 °F in the control.

Table 2—The number of days for June, July, and August 1982 that average and maximum temperature was greater than or equal to 60 °F, for soil depths of 1, 2, and 4 inches

Depth	June		July		August	
	B	UB	B	UB	B	UB
Average						
1 inch	6	0	17	2	2	2
2 inches	6	0	16	0	0	0
4 inches	4	0	10	0	0	0
Maximum						
1 inch	22	25	31	29	28	30
2 inches	19	22	29	26	28	30
4 inches	19	4	28	12	20	26

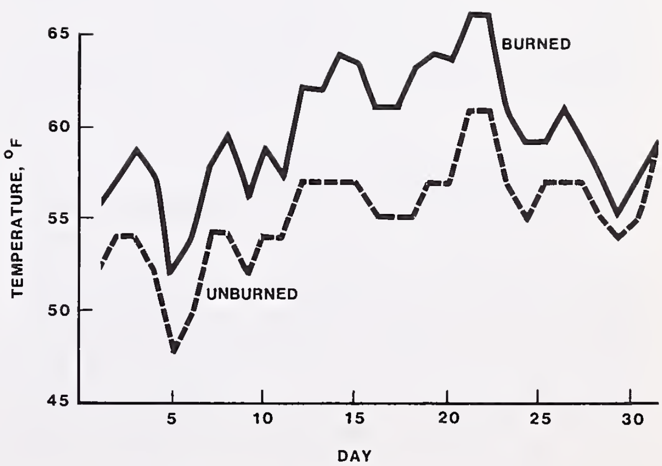

Figure 1—Daily average soil temperatures at the 1-inch depth on the burned and unburned treatments in July of 1982.

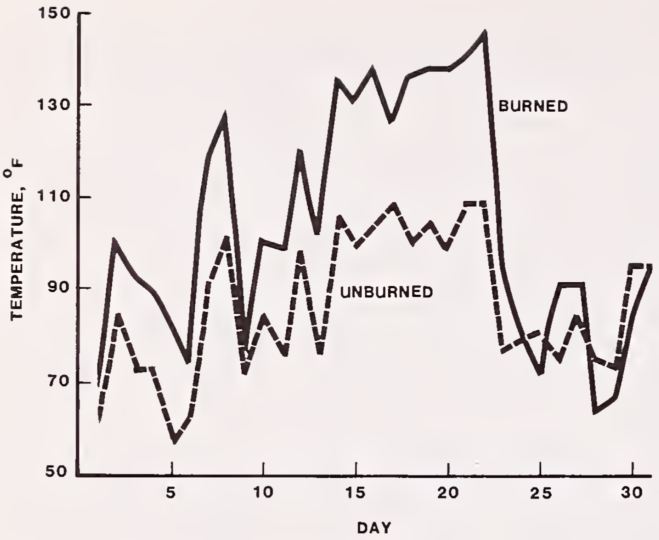

Figure 2—Daily maximum soil surface temperatures on the burned and unburned treatments in July of 1982.

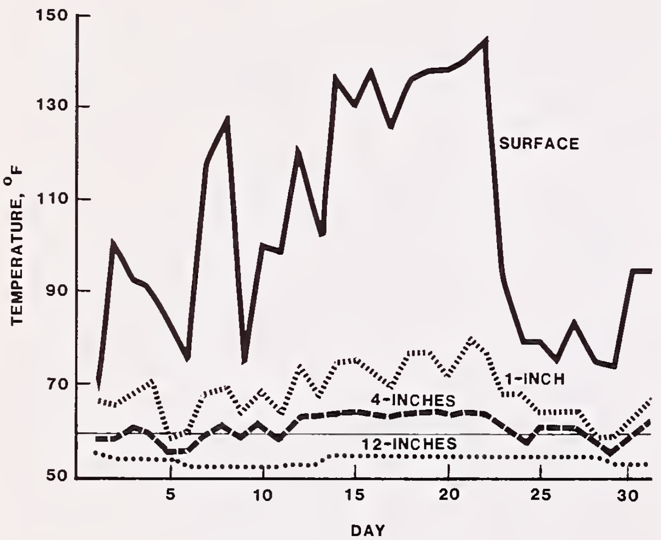

Figure 3—Daily maximum soil temperatures on the burned treatment for the surface, 1-inch, 4-inch, and 12-inch depths in July 1982.

RELATIONSHIP OF SOIL TEMPERATURE TO SUCKERING

Sucker response on the burned treatment varied from 4,500 to 15,000 suckers per acre (Brown 1986). More than 15,000 suckers per acre emerged in year 1 in a plot 300 feet from where temperatures were measured (Brown 1986). In the control, fewer than 1,000 suckers per acre emerged in year 1. The number of suckers observed is consistent with other results (Bartos and Mueggler 1982; Schier and Campbell 1980; Schier and Smith 1979), and is sufficient for reestablishing a good healthy stand of aspen. Most of the suckers (56 percent) originated from depths of 2.3 inches or less, with 91 percent from above 4.7 inches.

Maximum temperatures were above the hypothesized 60 °F threshold most of the time in year 1 (table 2). Daily average temperatures in year 1 were also above 60 °F enough that average temperatures were not limiting. Comparing the measured variable regime with Zasada and Schier's (1973) poor response at the regime of 68/50 °F, I find that maximum temperatures exceeded 68 °F on 29 days and minimum temperatures exceeded 50 °F on 60 days at the 1-inch depth. Thus all measures of temperature at this site relative to the 60 °F threshold would indicate that suckering is not limited by temperature on the burned treatment. The literature does not clearly establish whether sucker response is influenced by average temperatures, maximum temperatures, a variable temperature regime, or accumulated heat units (degree days). Maini and Horton's (1966b) laboratory results demonstrated that average temperatures of 58 °F or less reduce the initiation of suckers. In addition to temperature, other factors such as carbohydrate reserves (Schier and others 1985), clonal variability (Schier 1981), and hormonal balance (Eliasson 1971a, 1971b; Schier 1981) influence suckering of aspen. The interaction between these variables is not well understood.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

The results of this study show that following prescribed burning temperatures at the soil surface to depths of 12 inches increased significantly when compared to the undisturbed stand. Rapid regrowth of understory vegetation and emergence of aspen suckers shaded the burned treatment in years 2 and 3, reducing temperatures to the level of the control. Temperature data compared to the sucker response data clearly show that, following burning, soil temperatures at depths to 4 inches were favorable for sucker initiation. Thus, these results do not provide a conclusive test for the hypothesis that temperatures less than 60 °F are limiting to suckering. Temperatures often exceeded 60 °F on the burned treatment and sometimes on the untreated area. Field experiments that limit soil temperatures to less than 60 °F while apical dominance is broken in a number of clones would provide a critical test for the 60 °F hypothesis.

The Manning Basin site is typical of many aspen stands in the northern and central Rockies. Sites with lower elevations and more southerly to westerly exposures are likely to have warmer soil temperatures than Manning Basin. Sites with warmer temperatures will not have temperature limitations to suckering. Sites with northerly exposures or at higher elevations, or both, may have lower soil temperatures than measured at Manning Basin. These lower temperatures may limit sucker initiation.

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